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L. O. HOWARD, Entomologist and Chief of Bureau.

THE INDIAN-MEAL MOTH
AND
"WEEVIL-CUT" PEANUTS.

BY

C. H. POPENOE,

Entomological Assistant, Truck Crop and Stored Product Insect Investigations.

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TRUCK CROP AND STORED PRODUCT INSECT INVESTIGATIONS.

F. H. CHITTENDEN, *in charge.*

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE INDIAN-MEAL MOTH AND "WEEVIL-CUT" PEANUTS.

By C. H. POPENOE,

Entomological Assistant, Truck Crop and Stored Product Insect Investigations.

Until a few years ago the peanut had been considered as almost immune from insect injury, the plant being affected by few insects, and the "nuts" being protected by their thick shells against most of the usual insect enemies of stored products. There are, it is true, one or two species of beetles which by reason of their horny jaws are able to cut readily through the woody tissue, but the injury from any of these had been infinitesimal.

Since the advent of the mechanical thrasher or "peanut picker" conditions have changed to a great degree. The machinery is by no means perfect as yet, and the tendency of the operator to feed the peanuts too quickly through the machine results in a large percentage of broken shells, and affords easy entrance to several of the common stored-product pests. It is estimated that between 20 and 30 per cent of the peanuts are injured in this manner, consequently becoming "seconds," and in nearly every case becoming infested in a short time after being stored.[1]

Another source of injury to the shells of the peanuts, affording ingress to insects, is the practice of piling the sacked nuts high in the storage warehouses. This makes it necessary for the workmen to climb upon the stacks of sacked peanuts, thus breaking many more, and increasing the percentage of infestation.

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[1] At a meeting held June 14, 1911, at the Department of Agriculture, Washington, D. C., which was attended by many prominent peanut dealers, chiefly from Norfolk, Suffolk, and Portsmouth, Va., and from North and South Carolina, the question of how to treat "cut" peanuts was discussed by Mr. Popenoe and by the writer, and an agreement was reached to undertake the project of testing remedies for peanuts in store. The value of the peanut industry for 1910 was estimated at $15,000,000. Assuming the percentage of insect injury to be the same as that to stored cereals, the loss to the peanut dealers would be 20 per cent, or, at a conservative estimate, $3,000,000. One prominent dealer was about to abandon the industry because of insect injury. In tidewater Virginia, where a preliminary investigation was made, Mr. Popenoe was assisted by Mr. F. A. Johnston and by Mr. W. R. Beattie, of the Bureau of Plant Industry. Indeed, it was owing to the services of Mr. Beattie that this investigation was begun. The accompanying circular is being issued by request of the peanut growers.—F. H. CHITTENDEN.

The insect chiefly concerned in the injury to stored peanuts is the larva of a small dusky moth, commonly called the Indian-meal moth (*Plodia interpunctella* Hbn.), a common and well-known pest, habitually frequenting all places where foodstuffs and cereals may be stored, and feeding, as its name would indicate, upon meal, flour, and grain. It also attacks dried fruits, nuts, chocolate, and seeds. Like other related species, it prefers darkness or semidarkness, although at times seen abundantly in well-lighted storerooms.[1]

DESCRIPTION OF STAGES.

The adult or moth, shown in the accompanying illustration (fig. 1, *a*), is about one-half to three-fourths of an inch in expanse of wings. The outer two-thirds of the forewing is of a reddish brown color with a coppery luster, while the inner third is whitish gray, giving the insect, while resting, the appearance of being cloaked. The hind wings are dusky gray. The larva, shown at *c*, *d*, and *e*, in the figure, is dirty whitish, varying at times from greenish to a decided pink cast. It is about one-half of an inch in length when mature. The pupa, shown at *b*, is about three-eighths of an inch in length and light brown in color. It is inclosed in a cylindrical silken cocoon or web, which may be mixed with frass. The eggs are small and white, and are deposited upon the food substance selected, either singly or in groups of three to a dozen.

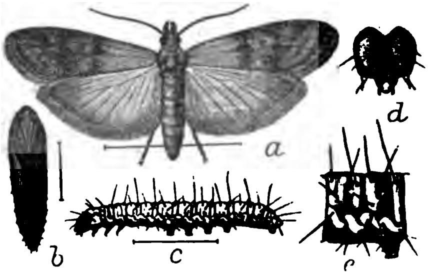

FIG. 1.—The Indian-meal moth (*Plodia interpunctella*) : *a*, Moth ; *b*, chrysalis ; *c*, caterpillar ; *d*, head ; *e*, first abdominal segment of caterpillar, more enlarged. (From Chittenden.)

LIFE HISTORY AND HABITS.

The moths usually make their appearance in numbers, in Virginia, by about the middle of June, and may be seen flying in the darker portions of the storage houses or resting upon the sacks of peanuts.

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[1] In addition to the Indian-meal moth, several other insects are frequently found to injure peanuts in storage. These, in the order of their importance, are as follows: The rust-red flour beetle (*Tribolium navale* Fab.), the saw-toothed grain beetle (*Silvanus surinamensis* L.), the cadelle (*Tenebroides mauritanicus* L.), the fig moth (*Ephestia cautella* Walk.), and the Mediterranean flour moth (*Ephestia kuehniella* Zell.). The three former species are capable of cutting through the shells of peanuts, but rarely occur in such numbers as to be injurious to them. They are amenable to the remedies mentioned in this publication.

In unheated houses the first eggs are laid in March and April by the moths just issuing from the pupal stage. At this time they are comparatively scarce and are little noticed; but later, when the successive generations have been allowed to multiply, they become very abundant, reaching their maximum in the latter part of August. In heated rooms reproduction may be continued throughout the winter.

The eggs hatch in about 4 days after deposition, and the larvæ at once begin the work of destruction. The larval stage may be considered to last about 18 days, varying according to weather conditions. During this time the larvæ crawl from one kernel to another, feeding as they go, and spinning a quantity of silken thread, which, mixed with food particles and excrement, disfigures and injures the material over which they crawl. When the nuts have been attacked for some time the entire mass resembles a mat of webbing mixed with powdered food material and frass. When fully mature the larvæ crawl about, seeking a place for pupation and spinning large quantities of web as they go, finally making, in cracks in the flooring, between bags, or in other dark places, cylindrical silken cocoons, in which the larvæ transform to the pupal stage. In hibernation the larva remains throughout the winter in the cocoon, in a state of quiescence, pupating early the following spring.

The pupal stage usually lasts from 5 to 10 days before the issuance of the mature insect, making the life cycle, under good conditions of temperature, from 4 to 5 weeks and affording opportunity for from 4 to 7 broods or generations of larvæ in one year. As the female is capable of depositing from 300 to 400 eggs, it may be seen that the capacity for injury is considerable.[1]

NATURAL ENEMIES.

This insect has a number of natural enemies, the most prominent being two hymenopterous parasites, *Omorgus frumentarius* Rond. and *Hadrobracon hebetor* Ashm. These two forms do much to check the multiplication of this and other similar pests.

REMEDIAL MEASURES.

Although at first sight this insect seems to present a problem to the packer, its control is by no means so difficult as might be supposed. At least two effective methods of control are applicable, namely, heat and fumigation.

The heat method of control.—The treatment by heat, while new in its application to entire buildings, has during the past two years been used very successfully, both in the control of the Indian-meal moth and in that of the related Mediterranean flour moth. Both Prof. G. A. Dean, of the Kansas Agricultural Experiment Station, and the author have used this method in the control of the flour moth, and it was used quite successfully by the latter in a peanut mill in Virginia. It is, of course, only applicable to mills heated by steam. In the proper application of this method the mill should be thoroughly piped and furnished with suitable radiators. Sufficient radiator surface should be supplied to obtain a temperature of 120° to 125° F. A few courses of 1¼-inch pipe placed along the side walls should easily bring about the desired results. If a warm day in the summer is selected and the steam is employed at a pressure of 75 to 100 pounds, only a small amount of radiator surface is needed. To permit the most effective penetration of the heat, the bags of nuts should be piled only a few feet deep, as experience has shown that some time is required for the peanuts within the piles to be raised to a uniform high temperature. The building should be closed tightly and the temperature raised to 120° F., remaining at this point for at least 6 hours. A longer time is advisable, as the penetration is thereby increased. Bags of shelled stock are with difficulty heated to the center without a long exposure, and although the larvæ work near the outside of the bags they may crawl to the center to escape the great heat, which tends to make them much more active.

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[1] The description of stages and notes on the life cycle are compiled largely from the work of Dr. F. H. Chittenden, published in Bulletin 4, new series, of the Bureau of Entomology, United States Department of Agriculture.

The temperature should not be raised above 125° F. in the case of peanuts, as experiments have shown that a slight degree of blanching, or slipping of the "skin," takes place in shelled Spanish nuts exposed to such a heat. Virginia peanuts, being much less oily, are not affected, while no injury whatever takes place in the case of unshelled nuts. Germination is likewise unaffected, peanuts exposed 6 hours to a temperature of 140° germinating better and more quickly than those unheated. A temperature of 116° is fatal to insect life in a short time, larvæ, pupæ, and adults of the Indian-meal moth dying in less than one-half hour, when exposed.

Fumigation.—In mills and storehouses where the heat method is inapplicable, it may be necessary to fumigate with hydrocyanic-acid gas. *On account of the extremely poisonous nature of this gas care is necessary in its use*, and, where careless or ignorant help is employed, some danger might accrue through improper or careless handling. Before the gas is applied the building should be tightly closed; afterwards jars containing the requisite amount of diluted sulphuric acid should be placed therein, and the paper bags containing the cyanid of potassium dropped into these jars, thus liberating the gas in the room. This gas is used extensively as a remedy for flour-mill and household insects, and where intelligently handled gives excellent results. Full directions for its use are given in Circular 112 of this bureau.[1]

Carbon bisulphid is also applicable as a fumigant, and is highly effective, although its great inflammability and the possibility of its explosion when ignited are in a measure against its use.

MEANS OF PREVENTION BY THE PACKER.

In order to decrease the liability of peanuts to insect injury, the factory should be kept as free as possible from an accumulation of moths during the summer season. To this end, all cars of infested peanuts coming into the factory should be fumigated before entrance. The factories should be so constructed as to furnish as few hiding places for the larvæ and pupæ as possible. A modern reenforced concrete structure with concrete floors may be, with proper attention, kept almost entirely free from the pests.

The writer has seen large numbers of the larvæ hibernating between the two layers of a double floor that was apparently tight, and with ease resisting ordinary efforts to diminish their numbers. All cracks and crannies large enough to hold a small quantity of dust may also prove breeding places for the larvæ.

Care in attending to the freedom of outgoing freight cars from larvæ will also be of value in controlling the injury due to insects. An ordinary freight car can be easily and safely fumigated at a cost not to exceed $1, with either hydrocyanic-acid gas or carbon bisulphid. Even a thorough cleaning of the car before reloading will be of value in destroying many insects brought in with the previous shipment.[2]

The storage rooms should be light and airy, and the peanuts should not be piled so high that it is necessary to climb about on the bags in order to reach the top of the piles. While some degree of immunity may be reached by the storage of peanuts in large bulk, still the increased amount of breakage from this method more than balances the good effects of the bulk storage.

The storage of peanuts in elevator bins holding several thousand bushels each does not meet with this objection, as in such case the nuts are trampled but little, and the injury by insects is limited almost entirely to the top layer, rarely extending more than a foot or two below the surface.

MEASURES OF PREVENTION BY THE GROWER.

Infestation of peanuts by the Indian-meal moth frequently takes place in the storage sheds or barns of the farmer or grower, where the nuts are held in reserve and only sold as needed. Where the nuts are held over the summer, the moths are allowed to breed freely, with the result that many nuts that would otherwise escape infestation are ruined. Storage in dark, dusty lofts or sheds also allows greater increase of the insects by providing a suitable breeding place. Nuts which have been held for several years by growers frequently show large numbers of infested kernels. It is urged in this connection that unless in exceptionally good condition with regard to broken shells, no nuts should be held in the granary of the farmer later than the 1st of June, at which time the injury by the first generation or "brood" is just beginning. When held later, without proper fumigation and attention, the multiplication of the pest is unchecked, with the result that the grade of the nuts is materially reduced.

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[1] Circular 112, Bureau of Entomology, United States Department of Agriculture.

[2] Care should be taken that railroad agents deliver for peanut shipment only clean cars.

Of primary importance is the proper selection and operation of the peanut picker or thrasher. There are several types of this machine on the market, which with careful use may be depended upon to break a minimum amount of the shells. The almost universal cause of such injury is the practice of crowding the machines in order to thrash a larger quantity of nuts in a short space of time. This practice is reprehensible, as it is responsible for the large amount of broken peanut shells found in machine-picked nuts. While more profitable to the thrasher, its expediency seems doubtful, as the grade of the nuts is thereby reduced and the opportunity for infestation increased, thus reducing the price obtained for the product. The peanut packer will readily pay a higher price for an article in which he can be assured of a maximum number of fancy nuts. It is therefore suggested that proper attention be paid to the operation of the picker, and that care be taken that the machine is not crowded. This will result in much less breakage and so diminish the infestation that there will be little need of further precaution in the matter of storage.

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BUREAU OF ENTOMOLOGY—CIRCULAR No. 143.
L. O. HOWARD, Entomologist and Chief of Bureau.

INSECT DAMAGE TO STANDING TIMBER IN THE NATIONAL PARKS.

BY

A. D. HOPKINS,
In Charge of Forest Insect Investigations.

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

INSECT DAMAGE TO STANDING TIMBER IN THE NATIONAL PARKS.[1]

By A. D. HOPKINS,
In Charge of Forest Insect Investigations.

CHARACTER OF THE DAMAGE.

The damage by insects to the living trees of the forests and ornamental grounds of the national parks consists of injuries to the foliage, branches, or the entire tree which mar or destroy their attractive, educational, and historic features and diminish or destroy their commercial value.

Throughout the forests of the Rocky Mountains and Pacific slope, including the national parks, a large percentage of the timber has died during the past half century. The old standing and fallen dead trees, the red foliage of those that died last year, and the fading tops of those now dying bear evidence of the work of insects and are conspicuous examples of a great waste of forest resources. In some localities a few scattering trees die each year within a township or section; in others, clumps of trees or whole forests die during a single year.

The conifers, which are the predominating trees of this western part of the country, are subject to a high death rate from insect attacks. The pines, the spruces, the Douglas fir, the balsam firs, the hemlocks, the cedars, and the Sequoias (redwoods) have each at least one destructive enemy.

In the fall, spring, and early summer the dying and recently dead trees are conspicuous on account of their fading, yellowish-red, and reddish-brown foilage, as if injured by fire. When they are in large patches, or extend over a considerable area, their death is often attributed by the casual observer to forest fires.

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[1] This paper was read by the author at a conference of national park superintendents held under the auspices of the Secretary of the Interior, September 11-12, 1911, and is embodied in the proceedings of the meeting issued by the Interior Department.

EXTENT OF THE DAMAGE.

The extent of the damage to the forests by insects through the accumulation of dead timber and the dying of matured trees over large areas is vastly greater than the general observer would suppose. In fact, the dead and fallen timber is so common in all forests that it has heretofore been recognized as a natural and inevitable condition. Large areas of insect-killed timber have been charged to fire without further thought or examination to determine the real cause. Fallen timber has been attributed to storms, and scattering dead trees to old age.

During the present year a reconnaissance was made of typical sections in one of the national forests, where there was no evidence that destructive forest fires had occurred during the past 20 years. It was found that the standing and fallen dead yellow pine that had died within that period amounted in board feet to nearly half as much as that which was then living, and of the sugar pine and Douglas fir there was one-fourth as much dead as was then living, and every dead tree examined in the estimate showed evidence that it had been killed by insects.

In the Black Hills National Forest of South Dakota over one-half of the timber died within a period of about 10 years. In Oregon and Montana nearly all of the larger pine died within a few years on areas of a few hundred acres to 100,000 acres or more. These together with many other examples of extensive dying of timber have been investigated and found to be caused primarily by insects. Investigations have also demonstrated beyond question that a vast amount of timber is killed by insects every year within the forested areas of the Rocky Mountain and Pacific Coast regions. Furthermore, the accumulation of this dead timber and fallen débris is a menace to the living, because it furnishes fuel for destructive forest fires. The losses from insect depredations are thus augmented by fires.

The extent of damage to the forest and other trees of the national parks has not been estimated and, with the exception of investigations conducted in the Yosemite and Glacier Parks, we do not have much direct information as to the damage already done. It is plain to us, however, that the general conditions are not different from those which prevail throughout the regions in which the parks are located and in which the destructive species of insects are known to occur.

The amount of damage in the parks must be considered not only on the basis of the commercial value of the forest resources, but on that of the æsthetic and educational value of the virgin forest with its typical examples of tree species.

The loss of a section of the forest which forms the attractive feature in the landscape, or is the only remaining example of the original type of forest growth of that region, is far greater than that represented by the commercial value of the timber; as is also the loss of notable veterans and giants of the different species. These old forests and old trees are at present one of the attractive and instructive features of the timbered areas of some of the national parks, and if they are protected from their insect and other enemies they will be even more attractive features in coming centuries. Under present conditions, these old trees of the virgin forest are in greater danger of being killed by insects than are the younger trees. Indeed, many of them have been killed within recent years.

The three giant sugar pines on the trail from Wawona to Glacier Point and the Yosemite Valley are examples. Two of them were dead and the other was dying when I saw them in June, 1904, and there was conclusive evidence that their death was caused by the mountain pine beetle. The veteran sugar pine, known as "Uncle Tom," was being attacked at that time by the same species of beetle, and I am informed that it died the following year. The loss of these four giants of the species is irreparable.

The Sequoias are supposed to be immune to the attack of insects, but they are not. They are more resistant than other species, and that is one reason they have lived so long. However, each species has a barkbeetle enemy which, under favorable conditions, is capable of killing the largest and finest specimens. I saw one of the large redwoods in the vicinity of Eureka, Cal., that had been killed by its barkbeetle enemy, and when in the Mariposa Grove, in 1904, I discovered the barkbeetle enemy of the big tree in the living bark of a storm-broken limb.

THE PRINCIPAL DEPREDATORS.

The mere mention of the names of the thousands of species of insects, each of which causes some peculiar injury during the life of the different tree species, would occupy more space than is allotted for this paper. Therefore we must consider the more important of those which are directly responsible for the death of the trees.

The little genus of Dendroctonus beetles, or tree-killing beetles, is represented in the Rocky Mountain and Pacific Slope regions by a few species which are more destructive to the conifers of western North America than all other forest insects combined. They are a constant menace to the pine, spruce, and Douglas fir of the national parks. They are certain to be present in every park in which there are forests of their host trees, and have doubtless caused far greater damage than the park officials have realized.

The species, in the order of their destructiveness, are the mountain pine beetle, the western pine beetle, the Engelmann spruce beetle, the

Jeffrey pine beetle, and the red turpentine beetle. All but the Jeffrey pine beetle of the Sierras are common to the northern Rocky Mountains and the Pacific Slope. Those common to the central and southern Rocky Mountains are the Black Hills beetle, the Engelmann spruce beetle, the Douglas fir beetle, and the red turpentine beetle. There are three other species common to the southern Rocky Mountains and northern Mexico which are of less importance in causing the death of trees.

These insects are small, stout, black to reddish-brown beetles, ranging in length from about 2 mm. to 9 mm., or 0.08 to 0.36 of an inch. They fly in the period from April to October and attack the main trunks of the living healthy trees by boring into the bark and excavating long winding or nearly straight egg galleries between the bark and wood. In this manner they completely girdle and thus cause the death of their victims. As soon as the bark begins to die the eggs deposited by the beetles hatch and the young grubs, or larval forms, complete the destruction of the inner bark. All of the broods develop into the adult stage within a year and emerge from the bark to fly in search of new victims. Each species has its peculiar habits in the choice of host trees, methods of attack, and period of development.

THE MOUNTAIN PINE BEETLE.

The mountain pine beetle attacks the mountain or silver pine, sugar pine, western yellow pine, lodgepole pine, and evidently all other pines of the northern Rocky Mountains and the Pacific slope. The adult beetles fly in the period from July to October, inclusive. When abundant they concentrate their attack on clumps and patches of trees. Their long, nearly straight egg galleries and radiating larval mines soon kill the bark on the main trunks, but the foliage of the infested trees remains green and apparently healthy until the following May and June. It then begins to change to a pale green and later to yellowish and brown. By the time all of the foliage is dead, about the 1st of July, the overwintered broods of beetles begin to emerge. By the middle of August most of them are out of the dead trees and have entered the living ones.

This is by far the most destructive insect enemy of the pine within its range, and under present conditions is a constant menace to the forests of matured or merchantable-sized timber. It can be controlled by felling the infested trees and by removing the infested bark from the main trunks without burning the bark or tops. This work must be done during the period between the 1st of October and the 1st of July to destroy the broods of the beetle before they emerge. Whenever the timber can be utilized the product will pay all expenses. If it has no commercial value it will cost on an average

50 cents a tree for the required treatment. After an outbreak is under control the living timber can be easily protected from further depredations by giving prompt attention to the felling and barking of any clumps of dying trees found during May and June. Rangers or fire patrolmen can be instructed so that they can do this and anything else that is required to maintain control.

THE WESTERN PINE BEETLE.

The western pine beetle attacks the western yellow pine, the sugar pine, and the Jeffrey pine. The beetles fly in late June to October, inclusive, and usually attack scattering individual trees, often selecting the larger and older examples. The adults excavate winding egg galleries between the inner living bark and the wood and transform to the adult stage in the outer bark. The beetles begin to fly and attack the trees in June and continue the attack until October or November. The first generation develops and emerges in August to November, and the second generation passes the winter in the trees that are killed by it in the summer and fall.

The foliage of the infested trees begins to fade and turn yellow in a few weeks after the trees are attacked by this beetle. The summer broods of the first generation leave the trees by the time the foliage is reddish brown, but the overwintered broods do not emerge until the following May and June, in some cases several months after the foliage is brown.

This species is next in importance to the mountain pine beetle as a destructive enemy of the pine, and the two species often combine in their attack. In this combined attack the western pine beetle is a secondary enemy of the trees because it follows the attack of the other species. When it is the primary enemy it is responsible for the death of a few scattering trees each year throughout the forest, which results in the accumulation of dead timber. In the aggregate, this accumulative loss is very extensive, involving, as it does, the largest and best trees.

The insect can be controlled and the living timber protected from its ravages by felling the infested trees during the period between the 1st of October and the 1st of June and removing the bark from the main trunks and burning it. It is necessary to burn the bark because the broods of this species transform in the outer bark. They are not destroyed by simply exposing the inner bark, as is the case with the mountain pine beetle.

THE JEFFREY PINE BEETLE.

The characteristic habits of the Jeffrey pine beetle are similar to those of the mountain pine beetle, and therefore it requires the same treatment.

THE DOUGLAS FIR BEETLE.

The Douglas fir beetle attacks the Douglas fir, the big-cone spruce, and the western larch. The beetles fly in April and May and enter the living bark on healthy trees and on trees that have been injured by fire and those that have been recently felled. In habits of attack and general characteristics the Douglas fir beetle is similar to the mountain pine beetle, except that the former begins to fly earlier in the season and the foliage of the trees infested begins to die in the fall. It is very destructive to the Douglas fir throughout the Rocky Mountain region from British Columbia to Mexico, but is much less so on the Pacific slope, especially toward the coast. It can be controlled by felling the infested trees during the period between the 1st of September and the 1st to middle of the following April and removing the infested bark from the trunks without burning.

THE RED TURPENTINE BEETLE.

The red turpentine beetle is the largest species of the genus Dendroctonus. It begins to fly in April and is active until October and November. It attacks the pine and rarely the spruce. As a rule it confines its operation to the base or basal portion of the trunks. While its normal habit is to breed in the bark of stumps and logs of newly felled trees, it often infests the bark on healthy trees. It rarely kills a tree, but is the cause of a large percentage of the basal wounds known as "cat faces" and fire wounds, so commonly met with in the pine. This is a far more difficult species to control than the others because it breeds in the stumps of felled trees and the base of those killed by the other species or by fire. Valuable individual trees can be protected by cutting the beetles out of the bark as soon as their presence is indicated by masses of exuding resin mixed with reddish boring dust.

Wherever there are continued lumbering operations the red turpentine beetle confines its attack to the stumps, but in the national parks and private grounds where a limited amount of timber is cut, or where the ravages of the mountain pine and western pine beetles have been controlled, it is likely to cause more or less extensive damage to the living timber for a year or two after.

In combating the other beetles in the national parks, care should be taken to remove the bark from the stumps whenever they are found to be infested with this pest.

THE ENGELMANN SPRUCE BEETLE.

The Engelmann spruce beetle attacks the Engelmann spruce, blue spruce, and any other species of spruce found within its range, but does not attack the pine, Douglas fir, or balsam fir. It flies in the period from June to August and attacks the bark of the main trunks of the older or matured trees. Its habits are similar to those of the mountain pine beetle, except that it flies earlier in the spring. When the trees begin to die the needles fade to a pale green and fall before they change to yellow or brown, but the bare twigs present a grayish-brown appearance. The infested trees are easily located in the fall and early spring by the fallen needles and the bare twigs of the tops.

This species occurs from British Columbia to Mexico and at times is very destructive to the Engelmann spruce forests. It can be controlled by felling the infested trees and removing the bark from the main trunks during the period beginning with the 1st of October and ending by the middle to last of May.

THE BLACK HILLS BEETLE.

The Black Hills beetle is by far the most destructive insect enemy of the pine of the central and southern Rocky Mountains and the Black Hills of South Dakota. Its habits are similar to those of the mountain pine beetle, and the same methods are adopted for its control.

FAVORABLE CONDITIONS FOR THE BEETLES.

There are certain conditions in the administered as well as in the natural forests which contribute to the multiplication and destructive work of these Dendroctonus beetles. One of the most favorable conditions is an extensive forest of matured and old trees of pine or spruce, because in the beginning of an invasion such trees are more often the first to be attacked and killed. Trees in such a forest injured by lightning or storms often form centers of infestation in which the beetles increase to sufficient numbers to enable them to kill a few trees, and then the invasion is started, year after year increasing in force until a large percentage or all of the old timber is killed. The beetles then attack the young trees and often waste their energies on saplings, in which the broods fail to develop.

Drought.—It is a common belief that severe droughts weaken the trees and thus contribute to favorable conditions for the attack of the beetles. We have made a very thorough investigation of this subject and are led to conclude that exceptionally dry seasons are more unfavorable for the development of the beetles than are moderately humid ones, and that, therefore, droughts do not contribute to their multiplication.

Forest fires.—Forest fires contribute, to a limited extent, to the multiplication of certain species which breed in fire-scorched trees, but as a rule forest fires kill more beetles than they protect.

Commercial cutting.—Commercial cutting of timber may contribute to the multiplication of certain species which breed in the stumps and tops, but if the cutting is continuous the insects confine their attack to the cut-over areas and do not invade the living timber. Sporadic summer cutting, however, is dangerous. The odor of the cut wood attracts the flying beetles to the locality. This contributes to their concentration, and when the cutting is stopped they invade the living timber.

Secondary enemies.—The secondary enemies of the trees consist of numerous species which attack the bark and wood as soon as the trees become weakened and are dying from other causes. The Dendroctonus beetles are the primary enemies or leaders in the attack. The secondary enemies are, to a certain extent, their allies, and when very abundant may contribute to favorable conditions for rapid advance in the destructive movement, but more often they are dependents and scavengers, merely utilizing the dead and waste material. With rare exceptions these secondary enemies are not capable of killing trees on their own account.

UNFAVORABLE CONDITIONS FOR THE BEETLES.

The unfavorable conditions for the destructive work of these Dendroctonus beetles are to be found in administered forests where the ripe or matured timber is utilized and where the young timber is protected by the prompt disposal, during the fall, winter, and spring months, of any clumps of dying trees.

In other words, systematic forest management based on a knowledge of the principles of silviculture and forest entomology will soon present conditions so unfavorable for the Dendroctonus beetles that they can no longer exist as agents of destruction and waste.

The natural enemies of the beetles serve as a repelling force against the progressive development of an invasion. Indeed, they are among the principal factors which have prevented the extermination of certain of the more important forest-tree species. These natural enemies consist of parasites and predatory insects, which feed on all stages of the barkbeetles, and birds, which feed on the adults and young of the barkbeetles. Were it not for the fact that birds also feed on the predatory and parasitic insect enemies of the barkbeetles, and that such birds are limited in numbers, they might render the great service that is so commonly credited to them.

Insect diseases in the form of epidemics sometimes serve to bring an invasion under complete control, and unfavorable climatic conditions have been known to exterminate a species of Dendroctonus beetles within an area of thousands of square miles.

Therefore, although under natural conditions successive generations of the older trees are killed by their insect enemies, these in turn are checked or repelled by natural means, so that generations of younger trees take the place of their ancestors, and the forest as such is perpetuated.

Natural control the most expensive.—In the national parks, national forests, and private forests where the resources have a commercial value this natural control of the insect depredators on the timber is the most expensive and wasteful. Our friends, the enemies of the beetles, can not be depended upon to operate for the best interests of the Federal or private owner. They can, however, be made to render efficient service as the allies of the owner in an aggressive warfare by him against the invaders. In this capacity they are indispensable in the defense against renewed attacks and in the maintenance of conditions which will insure the future protection of the living timber.

GENERAL METHODS OF CONTROL.

It is through a knowledge of the habits and seasonal history of the various species of depredating insects, and the various complex factors operating for and against them, that forest entomologists are enabled to advise methods of procedure in practical control operations either to reduce or eliminate the favorable conditions for the multiplication of the beetles or to promote and utilize the factors that are unfavorable for their existence.

It is also through a knowledge of the characteristic evidences of their presence in the living and dying trees that we are enabled to give instructions to an experienced timber cruiser, forest ranger, or fire patrolman which will enable him readily to detect an infestation and report upon its character and extent.

Experiments with and demonstrations of methods of control have furnished up-to-date information on the essential requirements in conducting active control operations, which enables us to advise the most economical and effectual method to be adopted for each species of beetle, each species of tree, and each locality where an infestation prevails.

Therefore, if the symptoms are accurately described and information is furnished as to the local facilities for utilizing the infested timber or for treatment at direct expense, specific recommendations for successful control can be made without an examination by an expert.

The presence in any national park of quantities of dying pine, spruce, or Douglas fir that has not been caused by recent fires is evidence of the presence and destructive work of one or more species of the Dendroctonus beetles. An examination of the bark of the main trunks of some of the dying trees will usually furnish conclusive evidence, for if the trees are infested the characteristic work in the bark, as illustrated in the bulletins of the Bureau of Entomology, will be easily recognized.

The next thing to do is to determine the extent of the infestation, the kind of trees involved, and the facilities for disposing of the timber by sale, free use, or direct expense. Then the superintendent should report the facts to an expert and ask for advice and recommendations. If he will then proceed without delay to dispose of the infestation according to instructions given him, success in checking or completely controlling the pest is almost certain to follow.

If, upon locating an infested area, it is found to extend beyond the park boundary into adjacent privately owned timber or the national forests, cooperation or at least concerted action is required, because an important center of infestation is a menace to the living timber within a radius of 10 to 20 miles.

If the timber of a national park is healthy and centers of infestation are found in adjacent forests within a radius of 10 to 20 miles, the park superintendent should notify the owners. If, for any reason, the owners can not dispose of the infestation the park officials should help do it just as they would help in fighting a fire that was threatening the park. In like manner the Federal and private owners of healthy timber adjacent to a park should help dispose of any extensive infestation in the park, because it may be more of a common menace than a forest fire.

If this policy of cooperation for the general good is adopted and the essential requirements for successful control are strictly adhered to for a few years by the officials of the national parks, the national forests, and the principal private owners, the damage to living timber in the parks and on adjacent lands will be reduced to a minimum, and ultimately thousands of dollars in commercial and æsthetic values will be saved for every dollar of public or private money expended.

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L. O. HOWARD, Entomologist and Chief of Bureau.

FEB 27 1935

THE DYING HICKORY TREES:

CAUSE AND REMEDY.

BY

A. D. HOPKINS,
In Charge of Forest Insect Investigations.

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE DYING HICKORY TREES—CAUSE AND REMEDY.

By A. D. Hopkins,

In Charge of Forest Insect Investigations.

Within the past ten years a large percentage of the hickory trees has died in various sections throughout the northern tier of States from Wisconsin to Vermont and southward through the Atlantic States to central Georgia and to a greater or less extent within the entire range of natural growth of the various species.

CAUSE.

While there are several and sometimes complicated causes of the death of the trees, investigations have revealed the fact that the hickory barkbeetle[1] is by far the most destructive insect enemy, and is, therefore, in the majority of cases, the primary cause of the dying of the trees.

HOW TO RECOGNIZE THE WORK OF THE HICKORY BARKBEETLE.

The first evidence of the presence and work of this beetle is the premature dying or falling of a few of the leaves in July and August, caused by the feeding of the adult or parent

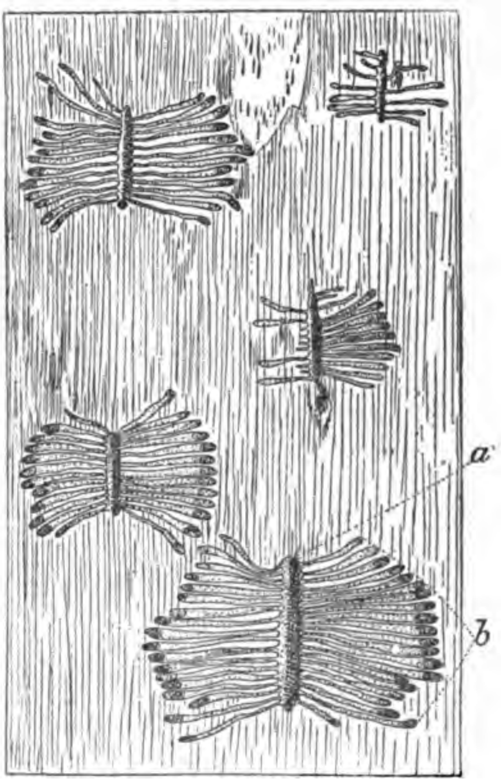

Fig. 1.—Work of the hickory barkbeetle (*Scolytus quadrispinosus*) on surface of wood beneath the bark: *a*, Primary gallery; *b*, larval mines. (Author's illustration.)

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[1] *Scolytus quadrispinosus* Say; Order Coleoptera, family Scolytidæ.

beetles at the base of the leaf stem (fig. 4), but this work alone does not kill the trees.

The next evidence of its destructive work is the dying of part of a tree or of all of one or more trees. If the trees are dying from the attack of the beetle, an examination of the inner bark and surface of the wood on the main trunks will reveal curious centipede-like burrows (figs. 1, 2) in the bark and grooved on the surface of the wood. These are the galleries and burrows of the parent beetles and of their broods of young grubs or larvæ. The girdling effect of these galleries is the real cause of the death of the trees.

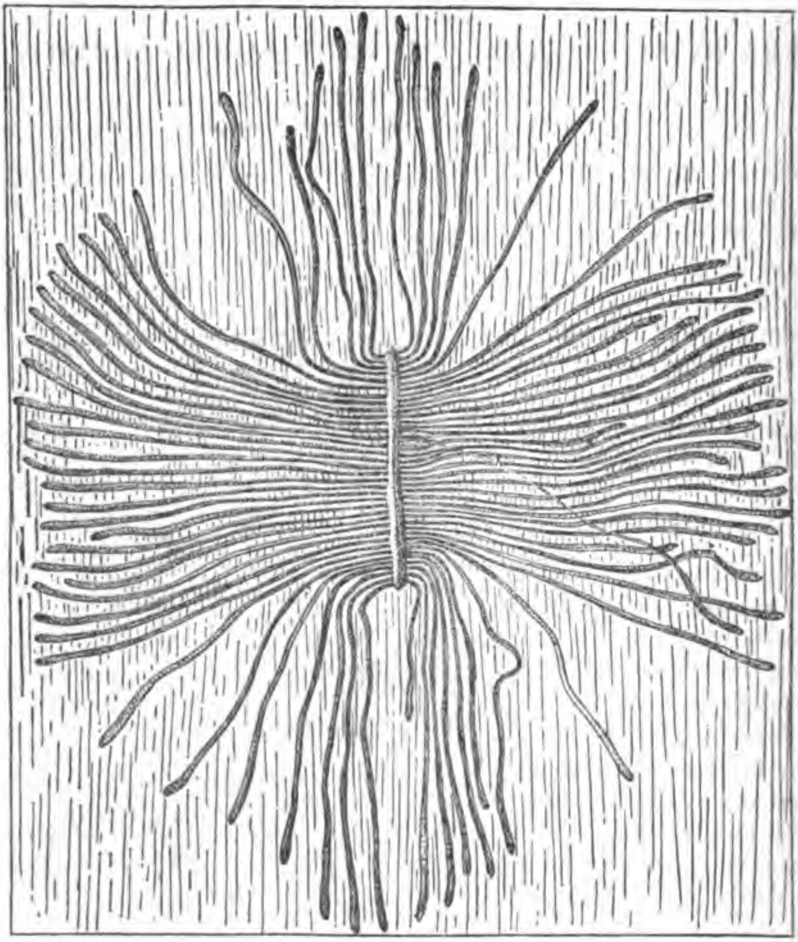

FIG. 2.—Complete brood galleries of the hickory barkbeetle on surface of wood. (Author's illustration.)

HABITS OF THE BEETLE.

The broods of the beetle pass the winter in the bark of the trees that die during the preceding summer and fall. During the warm days of March and April these overwintered broods complete their development to the adult winged form and during May and June emerge through small round holes in the bark (fig. 3) and fly to the living trees. They then attack the twigs (fig. 4) to feed on the base of the leaves and tender bark and also concentrate on the bark of the trunks and large branches of some of the living healthy trees and bore through the bark to excavate their short, vertical egg galleries (fig. 1, *a*). The eggs are deposited along the sides of these galleries and the larvæ hatching from them excavate the radiating food burrows (fig. 1, *b;* fig. 2), which serve to girdle the tree or branch.

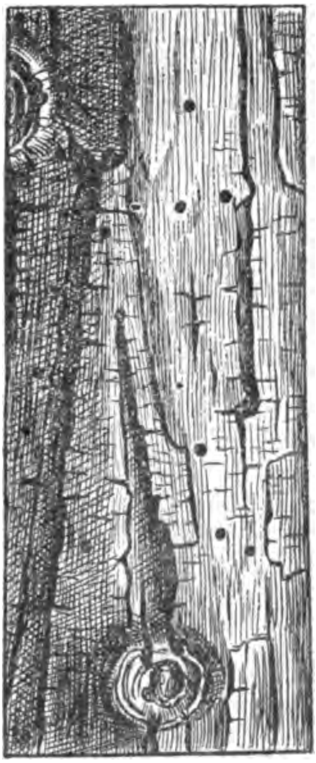

FIG. 3.—Exit holes in bark of hickory tree from which broods of the hickory barkbeetle have emerged. (Author's illustration.)

THE REMEDY.

The following recommendations for the successful control of this beetle are based on investigations, experiments, and demonstrations conducted during the past ten years.

RECOMMENDATIONS.

(1) The best time to conduct the control work is between October 1 and May 1, but it must be completed before the 1st to middle of May in order to destroy the broods of the beetle before they begin to emerge.

(2) Locate and mark the hickory trees within an area of several square miles that died during the summer and fall and those of which part or all of the tops or large branches died.

(3) Fell the marked dead trees and cut out all dead or infested portions of the remaining marked trees which still have sufficient life to make a new growth.

(4) Dispose of all infested trunks and branches in such a manner as to kill the overwintering broods of the beetles in the bark (*a*) by utilizing the wood for commercial products and burning the refuse; or (*b*) by utilizing the wood of the trunks and branches for fuel;

or (*c*) by placing the logs in water and burning the branches and tops; or (*d*) by removing the infested bark from the trunks or logs and burning it with the branches or as fuel.

(5) So far as combating the beetle is concerned it is unnecessary and a waste of time to dispose of trees or branches which have been dead 12 months or more, because the broods of the destructive beetle are not to be found in such trees.

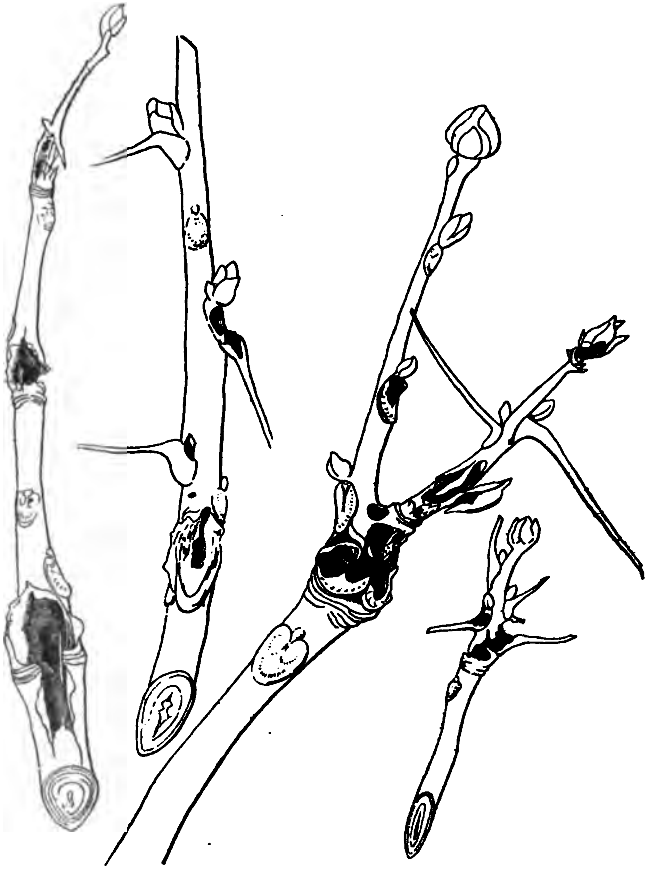

FIG. 4.—Injury by the hickory barkbeetle to the twigs, buds, and base of leaves. (Original.)

(6) Spraying the tops or branches or the application of any substance as a preventive is not to be recommended. Nothing will save a tree after the main trunk is attacked by large numbers of this beetle or after the bark and foliage begin to die.

(7) The injuries to the twigs (fig. 4) by this beetle do not require treatment.

(8) The bark and wood of *dying and dead* trees are almost invariably infested with many kinds of bark and wood boring insects

which can do no harm to living trees. Therefore all efforts should be concentrated on the disposal of the broods of the hickory barkbeetle according to the above recommendations.

To insure the protection of the remaining living trees it is very important that at least a large majority of the dead infested and partially dead infested trees found within an entire area of several square miles be disposed of within a single season in order to kill the broods of this beetle. Therefore there should be concerted action by all owners of hickory trees.

On account of the value of the hickory for shade and nuts and for many commercial wood products it is important that the people of a community, county, or State who are in any manner interested in the protection of hickory trees should give encouragement and support to any concerted or cooperative effort on the part of the owners toward the proper control of the hickory barkbeetle.

Approved:
JAMES WILSON,
Secretary of Agriculture.
WASHINGTON, D. C., *November 29, 1911.*

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Issued March 21, 1912.

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BUREAU OF ENTOMOLOGY—CIRCULAR No. 145.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE LARGER CANNA LEAF-ROLLER.

BY

F. H. CHITTENDEN, Sc. D.,

In Charge of Truck Crop and Stored Product Insect Investigations.

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United States Department of Agriculture,

BUREAU OF ENTOMOLOGY.

L. O. HOWARD, Entomologist and Chief of Bureau.

THE LARGER CANNA LEAF-ROLLER.

(*Calpodes ethlius* Cram.)

By F. H. CHITTENDEN, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

RECENT INJURY AND METHOD OF ATTACK.

During the year 1911 the leaf-rolling caterpillar of *Calpodes ethlius* Cram. attracted considerable attention from its abundance in most of the public parks in the District of Columbia, and at West Grove, Pa.; Norfolk, Va.; West Raleigh, N. C.; Memphis, Tenn.; Clinton, Miss.; Birmingham, Ala.; and Orlando, Fla. In earlier years it has ravaged fields of canna in portions of South Carolina and Alabama.

In September, 1904, a lot of specimens was received from Mr. L. H. Read, Fruitdale, Ala., who wrote that thousands of the caterpillars were in the fields and that hand-picking was out of the question. All bronze varieties of canna were injured, including 8 or 10 varieties. Among those most attacked were Mississippi, Mont Blanc, Explorateur Crampbell, and Italia. A few green varieties were somewhat affected, but as a rule were scarcely touched, obviously owing to their thicker and tougher leaves. The caterpillar was observed at work only at night. The same year the species was observed somewhat abundantly at Baton Rouge, La., by Prof. A. L. Quaintance, and sparingly at New Orleans, La., by Prof. E. S. G. Titus. Although only a few instances of severe injury are cited, these are doubtless merely representatives of many which were not reported.

August 27, 1905, the writer observed considerable injury by this caterpillar to many of the decorative canna growing on the grounds of the Department of Agriculture at Washington, D. C., and afterwards noted similar injury in several of the smaller public parks of this city, showing that the attack was not local, although more severe on the department grounds, which had attracted the butterflies from afar, doubtless owing to the much larger parkage. Caterpillars kept under observation had "spun up" for pupation by September 3, but at this time there were still many young larvæ present in garden plats, and there was evidence that they had been at work at least as late as the middle of August, while the age of the larva indicated that the butterflies had appeared to lay their eggs late in July, but evidently not earlier. The cause of this invasion was apparently that the summer of 1905 was an unusually hot one. Heat favors an increase of insects of this type. Prevailing southerly winds, however, were probably more potent factors in causing this migration from the Gulf region northward, since the summer of 1906 was still warmer, but with much greater humidity, and under these conditions only one pupa was found during that entire year.

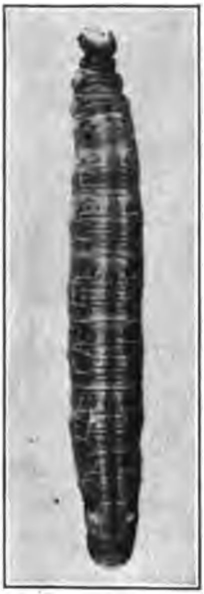

FIG. 1.—The larger canna leaf-roller (*Calpodes ethlius*): Full-grown larva. About one-third enlarged. (Original.)

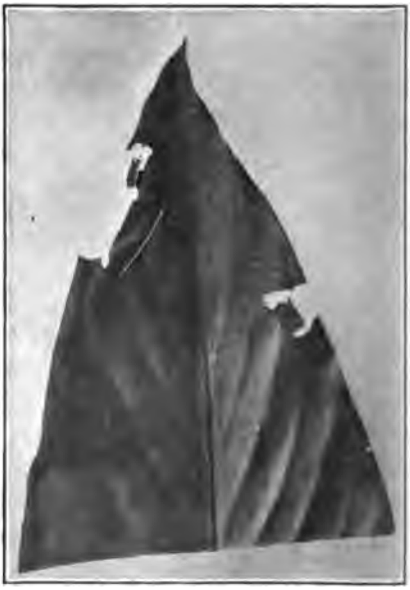

FIG. 2.—Canna leaf showing, at left, injury by an older larva of the larger canna leaf-roller. (Original.)

The attention of the writer was attracted to injury by this species by the large irregular areas which were cut away from the margins of the canna leaves. It was then noticed that the larva (fig. 1) begins operations by cutting a small, more or less oblong strip about one-half inch long from the edge of a leaf and folding it neatly over on the lower surface. (See fig. 2.) Within this flap, which is nearly flat, the larva lives concealed, feeding above and below its retreat. As it increases its growth the larva makes large incisions in the leaf's edge, with a correspondingly large flap (fig. 3). It is not until the larva is considerably larger that it forms large tubular retreats. (See fig. 4.) Rarely a larva folds a portion of the lower side of a leaf over the upper surface. This operation may vary under different conditions in other localities.

The following year, 1907, this species came under the observation of Mr. H. M. Russell, at Orlando, Fla., on August 24. At this time he found all stages in great abundance on canna, the leaves of which were being cut to pieces. Many plants were stripped of leaves down to the midrib.

A TROPICAL INSECT, KILLED OF BY FROST.

This species and its injuries have been known for many years, yet only one comprehensive article on it has, to our knowledge, appeared in any work on economic entomology,[1] although the insect in its various stages was described in detail by Dr. S. H. Scudder in his Butterflies of the Eastern United States and Canada.[2] The entire appearance of the insect from the larval stage to the adult is indicative of its tropical origin, and it is still somewhat restricted to the South. There is a possibility, however, that it may gradually extend its present distribution if it can obtain a footing in greenhouses where cannas are grown.

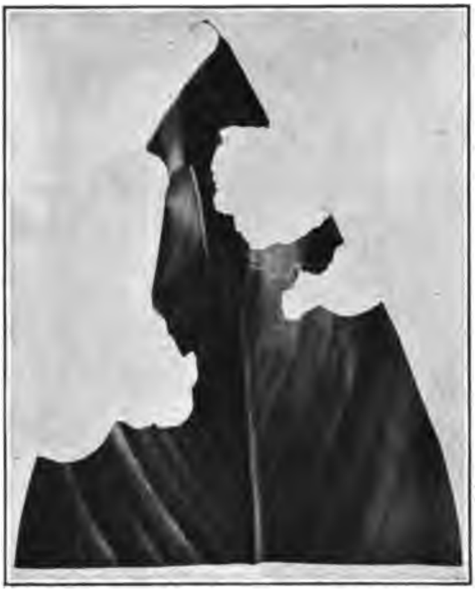
FIG. 3.—Canna leaf showing injury by still older larvæ of the larger canna leaf-roller. (Original.)

During 1911, at Washington, D. C., the writer obtained many specimens of rolled-up leaves of canna, some containing pupæ and larvæ, November 1; and later, November 3, after a frost of 28° F., 1 live pupa, 1 dead larva, and 2 dead pupæ were found. This material was placed under the same conditions as those under which it would have remained where found—that is, in the open—but none had transformed to butterflies up to November 22, showing quite conclusively that this material, which was carefully handled, would naturally have died under the circumstances. In the parks, when the cannas were cut, the immature stages in leaves were left for a day or two and afterwards presumably taken away where they would not have had an opportunity to transform any more than they would have had under the conditions previously mentioned. Several days later. November 27, only one living pupa was found, and this evidenced very little likelihood of ever recovering from the cold, showing conclusively that the species, unless it happens to find some unusually good place for hibernation, is "killed out" by the severe frosts of practically every winter. These conditions may even exist farther southward than the District of Columbia, wherever severe frosts are encountered.

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[1] Bul. 54, Bur. Ent., U. S. Dept. Agr., pp. 56–58, 1905. Data from this article have been incorporated in the present circular.

[2] Vol. II, pp. 1750–1757, 1889.

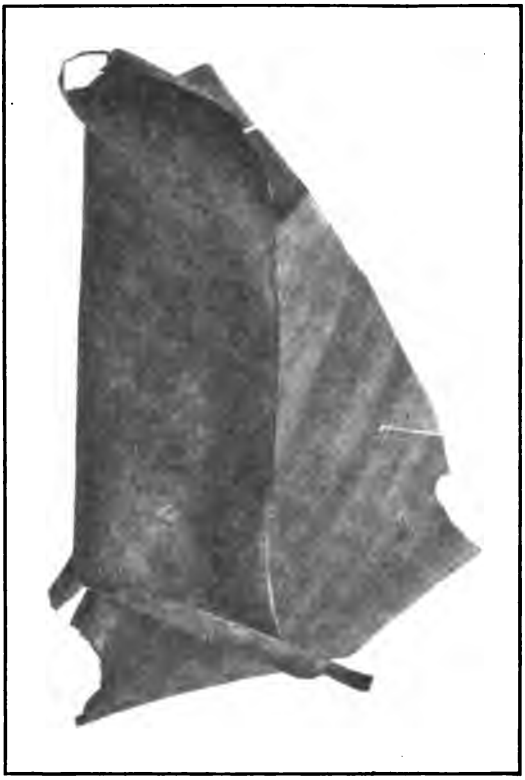

FIG. 4.—Section of canna leaf, showing edge rolled over and fastened by larva of the larger canna leaf-roller. Folded section taken the last of October, showing larger size than in summer. (Original.)

DESCRIPTIVE.

The butterfly.—The parent of this singular leaf-roller is a butterfly belonging to the subfamily Pamphilinæ of the family Hesperiidæ, or skippers. It is one of the larger skippers, with a wing expanse of between 1 and 1½ inches. The head is very broad, with large eyes, and the body is thick and heavy. The upper surface of the head, thorax, and a portion of the abdomen is thickly covered with long olive hairs. The wings are dark brown, with white semitransparent spots, arranged as in figure 6, *a*, which also shows the location of the masses of yellowish hairs, the contour of the wings, and the structure of the antennæ. The lower surface of the wings is much paler brown, or fulvous, and more nearly uniform in color. The head and body are still paler yellowish. The adult is sometimes called the Brazilian skipper.

The egg is illustrated by Scudder. It is subhemispherical in outline, as viewed from the side, and has a convex base, while the surface is very irregularly reticulated, in most cases pentagonally. The broadest diameter is 1.25 mm.; height about 0.7 mm. Eggs have not been seen by the writer, and the color does not appear to have been designated.

The larva, or caterpillar, is quite remarkable because of its semitransparency. Its surface is without hair, and the general color is moderately pale green, with dark-orange subtriangular head, which is marked by a frontal subtriangular space. The thoracic segments are greenish testaceous and more or less tinged with orange, at least in preserved specimens. The remainder of the body is nearly transparent, presenting a view of the vascular and nervous system beneath the skin, as illustrated in figures 1 and 6, *b*. The length of the larva, when full grown, is about 1¾ inches, but when fully extended it reaches 2½ inches.

The pupa is nearly as striking as is the larva. It is of similar pale greenish color and of the appearance shown in figure 6, *c*, *d*. The head is prolonged into a curved process, and the tongue extends in a nearly straight line considerably beyond the prolonged anal tubercle. Without the projections it is nearly as long as the unextended larva.

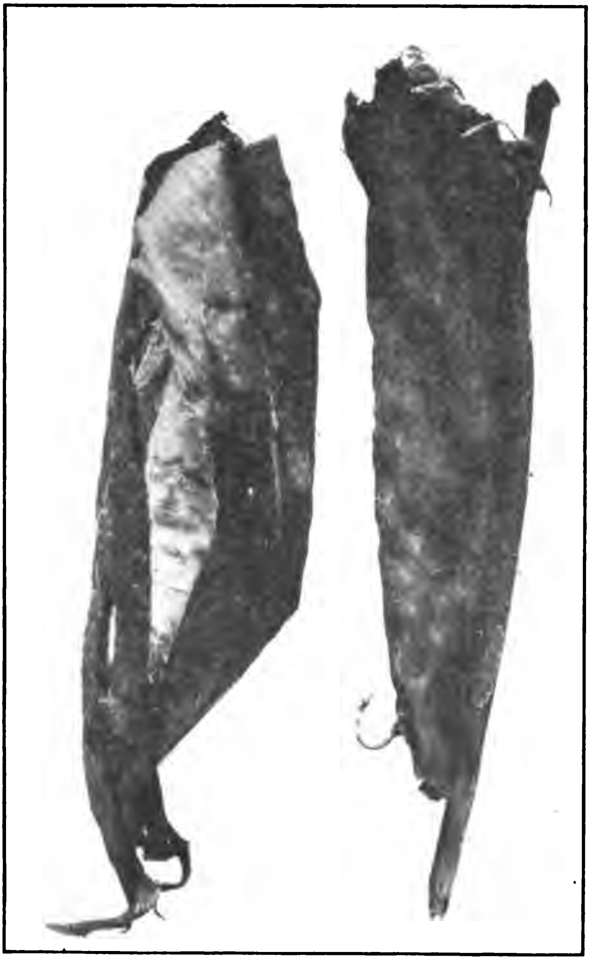

FIG. 5.—Work of larger canna leaf-roller: At right, tubular retreat from which the larva feeds, at left, same, showing pupa within. (Original.)

DISTRIBUTION.

Scudder states that the principal range of this species is from Central America to the northern parts of the South American Continent, although it inhabits also the extreme Southern States of our Union. So far as can be learned it is known to exist permanently only in the Gulf States, South Carolina, and Porto Rico in our domains. It also inhabits Cuba and Jamaica, however, and in South America occurs as far south as Argentina, where it was years ago reported to be common by Burmeister.

In an earlier article on this species (loc. cit.), Scudder's dictum was followed and the mentioned occurrence of this species at Bay Ridge, Long Island, and at New York City were considered as merely transitory. It is evident that such infestations may occur in the North whenever conditions favor the northward flight of the butterfly. These conditions have been mentioned. It is hardly probable that the insect successfully overwinters in the District of Columbia or northward, but that it flies in a northerly direction whenever there are favorable conditions for such a flight. Careful search was made by the writer in the parks of New York City in September and October of 1911, as also throughout Long Island to Riverhead, but there was no evidence whatever of the presence of this species in the State of New York that year.

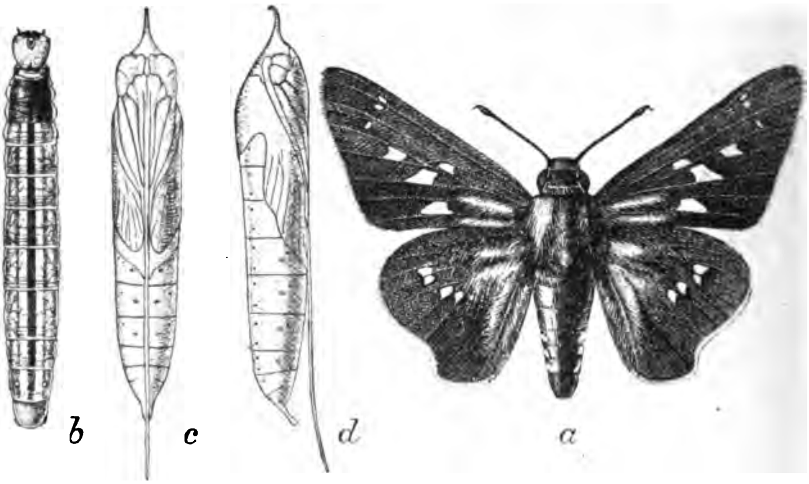

FIG. 6.—The larger canna leaf-roller (*Calpodes ethlius*) : *a*, Butterfly ; *b*, partly grown larva ; *c*, pupa, front view ; *d*, pupa, side view. Enlarged. (Original.)

EARLIER ACCOUNTS OF INJURY.

In the records of the Bureau of Entomology we have accounts of injuries and of other observations on this species, as follows: June 7, 1880, we received from Dr. J. H. Mellichamp, Bluffton, S. C., a report that the larva had utterly destroyed some luxuriant plants of *Canna flaccida* in his garden. August 9, 1887, we received from Mr. A. L. Townsend, Bay Ridge, Long Island, report that the species did much damage to French cannas and to *Caladium esculentum*. In our rearing cages the butterflies hatched June 12 and August 26.

The caterpillars appear to affect only plants of the genus Canna, when these are obtainable, and sometimes they are so abundant as to do much damage, at times utterly destroying luxuriant plants. Dr. H. G. Dyar, of the Bureau of Entomology, mentions a case in which the larvæ were eating the leaves of canna in the grounds of a hotel at Miami, Fla., considerably injuring the appearance of the plants.

LIFE HISTORY AND HABITS.

Eggs are laid singly and separately, sometimes in groups of from five to seven, on the under surface of leaves. According to Miss Helen King[1] they hatch in Texas in six days, while in Florida, according to Wittfeld, they may hatch in four days.

On hatching, the caterpillar, as is common with many species, devours a portion of its eggshell, whereupon, after feeding lightly on a leaf, it folds the latter over and confines it in place with a few stitches of silk, enlarging its retreat as it develops. From the tubular case thus formed it feeds along the edges and retreats within when disturbed. It is careful to eject all excreta and exuviæ, but in spite of its cleanliness the caterpillar is frequently attacked by disease.

Dr. Dyar[2] has ascertained that there are customarily five stages of this larva. The larva, when full grown, develops to a pupa in its resting place, "held by a transverse loop and a band of silk for the cremaster. * * * The cremasterial band is attached at one end to the leaf; at the other to the transverse thread." This accurately describes the pupal case as observed in specimens received at this office.

According to data accumulated by Scudder, the butterfly is on the wing in southern Florida in May, and from eggs laid in the middle of the month the butterflies reappear in the first half of June. In South Carolina the season is a little later, and there mature caterpillars have been observed before the middle of June and fresh butterflies from the 12th of the month to the end. Scudder concludes that there are two generations before midsummer. Judging by recent experience there are likely to be two more generations before cold weather, but we do not know how the winter is passed. The moths from one of these generations appear in the latter part of September.

Of the butterfly Angus has stated that he was attracted to an individual, which he captured near New York City, "by the peculiarity of its movements on the wing; they were very undulating, like those of gnats, as they rose and fell almost perpendicularly and in a very easy manner." Wittfeld adds that one of the favorite times for flight of the butterfly in fair weather is after sundown. Miss Helen King describes its motion as " very rapid."

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[1] Psyche, Vol. III, pp. 322–324, 1882.

[2] Entomological News, vol. 8, pp. 163–165, 1898.

VARIETIES OF CANNA MOST AFFECTED.

The question as to whether dark varieties of canna are more affected by this species than are green ones remains for further investigation. In the District of Columbia the green-foliage varieties which have come under the writer's observations are considerably more affected than the darker ones. When, however, the insect becomes very abundant it attacks all varieties. One correspondent, mentioned on the introductory page, has stated of the occurrence of this species in the Gulf region that it affects more particularly the dark varieties. A leaf showing severe injury by this species of leaf-roller is illustrated in figure 7, and a bed of cannas showing similar injury is shown in figure 8.

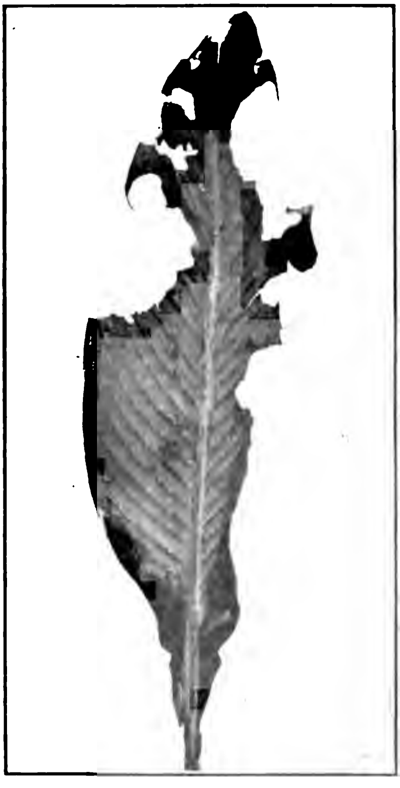
FIG. 7.—Canna leaf, showing advanced injury by larvæ of the larger canna leaf-roller. (Original.)

NATURAL ENEMIES.

In spite of years of experience with this species, neither Mr. Russell nor the writer has been able to observe any form of disease, but Mr. E. G. Smyth, when working under the writer's direction at Diamond Springs, Va., observed two larvæ killed by disease October 8, 1909.

During October, 1907, Mr. Russell found at Orlando, Fla., quite a number of egg parasites. October 12 he found a canna leaf on which were 33 eggs of this species, 5 unhatched, and 2 hatched larvæ; 26 of these eggs had given out parasites through a very minute hole in the side. October 16, 4 unhatched eggs were placed in one vial and 16 in another vial. November 1, while away, the eggs hatched out 20 minute parasites,[1] *Pentarthron minutum* Riley, as identified by Mr. A. A. Girault. In the other vial one larva hatched; the rest gave forth many minute parasites of the same species and one large unidentified parasite.[2] These observations, although few in number, show a high percentage of egg parasitism.

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[1] Chittn. No. 299^{01}.

[2] Chittn. No. 299^{02}.

METHODS OF CONTROL.

The rolled-over margins of the leaves of canna caused by this caterpillar can after a time be very readily detected while the larvæ are still young. (See fig. 2.) Later large holes will appear and the rolled-up leaves will be more prominent unless something is done to check the pest. The dark excrement will be found below the infested leaves and will also serve to indicate the presence of the larva, and after opening any of these rolled-over leaves the insect will usually be found therein, or traces of its former presence. All of these facts, together with the large size of the insect itself, permit its control by hand methods. Hand-picking was successfully practiced at Lafayette Square, Washington, D. C., in late July, 1911, and on the Department of Agriculture grounds, by squeezing the leaves with gloved hands. In the former locality the insects were very abundant; in the latter they were so well controlled by hand methods as scarcely to be noticed on the many canna plants which were grown.

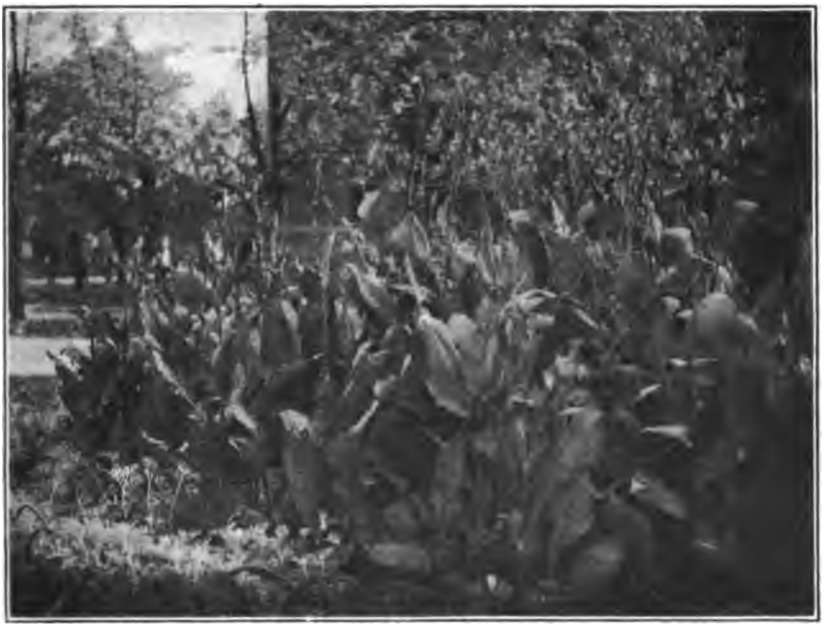

FIG. 8.—Bed of cannas showing serious injury by larger canna leaf-roller. Many leaves wilted and dying, or notched, as shown in foreground. Washington, D. C. (Original.)

The usual arsenicals, such as Paris green and arsenate of lead, with or without Bordeaux mixture, can be used without any real danger of poisoning. Their use is not always desirable, because of the presence of children, who are allowed to roam into yards which are not protected by gates; but this is not the case with our public parks, where the cannas grow in great profusion and are sufficiently protected by frames and where warning is always given by the officers in charge to keep away from the growing plants. These arsenicals may be used with a knapsack or other hand sprayer in just about the same manner as advised against the Colorado potato beetle in Bureau of Entomology Circular 87, a copy of which may be obtained on application to the Department of Agriculture.

It can not be too strongly emphasized that whatever method is used, whether spraying or hand-picking, should be inaugurated early in the season to prevent serious injury later on.

Approved:
James Wilson,
Secretary of Agriculture.

Washington, D. C., *December 29, 1911.*

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Issued April 26, 1912.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ENTOMOLOGY—CIRCULAR No. 148.

L. O. HOWARD, Entomologist and Chief of Bureau.

TWO DESTRUCTIVE TEXAS ANTS.

BY

W. D. HUNTER,

In Charge of Southern Field Crop Insect Investigations.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1912

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CIRCULAR No. 148. Issued April 26, 1912.

United States Department of Agriculture,

BUREAU OF ENTOMOLOGY,

L. O. HOWARD, Entomologist and Chief of Bureau.

TWO DESTRUCTIVE TEXAS ANTS.

By W. D. HUNTER,
In Charge of Southern Field-Crop Insect Investigations.

THE CUTTING OR PARASOL ANT.

(*Atta texana* Buckley.)

The so-called cutting or parasol ant (*Atta texana* Buckley) is well known to residents of the region in which it occurs. The colonies are located in sandy soil, generally in the timber, and consist of low mounds of considerable extent covered with numerous craters about 18 inches in diameter. The ants have the habit of cutting the leaves from a great variety of plants and of carrying them to their nests. In many cases the attack is concentrated on one tree, which may be entirely defoliated in a single night. The species is of a reddish-brown color. The colonies contain individuals showing great differences in size, as will be explained later.

DISTRIBUTION.

The range of this species is rather restricted. It is known only from a limited area in south-central Texas. This area extends from the Brazos River as far north as Waco to the Gulf, westward as far as San Antonio, and southward to the vicinity of Alice. The ant is most common in the valleys of the Colorado, Guadalupe, Comal, and San Antonio Rivers. In these situations it is evidently increasing in numbers from year to year. In many cases the nests occupy the land practically continuously for many miles up and down the valleys.

HABITS.

The nests consist of underground chambers with several openings or craters. The surplus openings seem to be provided for the purpose of ventilating the underground passages. The nests are located generally in sandy soil. The more compact soils seem to be unfavorable for their construction. A very common location for a colony is a sandy promontory, well lighted by the sun, in the bend of a river.

The large irregular mounds are due to the leveling by the wind and rains of the circular ridges of sand, brought from beneath the surface, which surround the openings. Consequently, each of the mounds is an indication of the activity of the ants for many years. Beneath these mounds are numerous chambers connected by narrow passages, and there may be direct connection by these channels over an area of several hundred square feet.

The habits of this insect have attracted great attention from scientists and others. The ants cut the leaves from trees and carry them to the nests. Each leaf is finely divided and made into small pellets. In this work the mandibles and legs of the ants are utilized. The small masses are placed upon the so-called fungus garden, where they furnish a growing medium for the growth of a fungus which furnishes the colony with food. As the supply of fungus is consumed the ants add to the old mass, so that eventually the nests are found to contain large spongy formations on the outer portion of which the slender threads of the fungus are growing. Evidently the ants exercise great care in preventing the contamination of the fungus garden by any but the sole species of fungus that is utilized.

The ant is active throughout the greater part of the year. In fact, it becomes quiet for only a very short time when the winter cold is most severe. It is disinclined to work during very hot weather. During the cooler months its activity extends throughout the day, but during the summer it is confined to the night. The distance over which foraging expeditions take place may be 200 yards or even more. Practically all species of plants seem to be suitable for food, although it is noticeable that only one species is attacked at a time. Dr. W. M. Wheeler, who has made very careful studies of these ants, has noted that the same colony may feed upon a wide variety of plants at different times, but he never observed the individuals of a colony collecting different varieties at the same time.[1] Among cultivated crops, cotton, corn, fruit trees, sorghum, and many others are attacked. Among wild plants, forest trees are favored, and frequently the Spanish moss is used. The various species of oaks seem to be more or less immune, either on account of the texture of the leaves or the tannic acid they contain. This immunity is by no means absolute, however, as Dr. Wheeler and Mr. J. D. Mitchell have observed the ants making use of such rough leaves as those of the live oak.

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[1] Wheeler, W. M. The Fungus-Growing Ants of North America. Bul. Amer. Mus. Nat. Hist., vol. 23, Article XXXI, pp. 729–742.

The colonies of this ant are formed by the flight of the females to some point not far distant from the nest. The queen alights, digs beneath the surface, deposits a small quantity of the fungus from the original nest, and on it deposits a number of eggs.

FORMS.

This ant occurs in five forms, namely, soldiers, large workers (media), small workers (minima), males, and females. The soldiers are from 10 to 12 mm. in length, with enormously developed heads. The large workers, or media, resemble the soldiers, although the head is somewhat smaller, and the length of the body is between 3 and 9 mm. The small worker forms, called minima, are from 1.5 to 2.5 mm. in length. The head is still smaller than in the media. Each of these three forms has a special function in the nest. The soldiers are concerned primarily with the protection of the nest. They do not sting, but bite with their mandibles, which are strong enough to draw blood. The large workers and small workers are busied principally with the gathering of leaves for the fungus garden and the preparation of the material on which the fungus grows. The remaining forms are the males and females. These are much larger than the other forms. The female is about 18 mm. in length. The color is dark brown, although the legs are somewhat reddish. The body is covered with dense tawny hair. The wings, which are shed soon after the flight of the queen, are reddish brown, especially along the anterior borders. The males are from 13 to 14 mm. long with a head of small size which contrasts greatly with that of the worker forms. The body is densely covered with long yellowish hairs, as is the case with the females.

REPRESSION.

The fact that this ant does not continue to attack one species of plant continuously, but changes from one to another at frequent intervals, causes it to be of less importance in the destruction of vegetation than it would be otherwise. Nevertheless, the damage to growing crops is frequently heavy, and complaints have become more numerous in recent years on account of the greater abundance of the ants. In many places considerable areas of land are not planted to crops on account of the danger of attack. In all such situations it is necessary to resort to repressive means.

The best method of control is undoubtedly by means of potassium cyanid.[1] Mr. J. D. Mitchell has conducted the experiments upon which this conclusion is based. He used 98 per cent potassium cyanid at the rate of 1 ounce to 1 quart of water. After careful mixing this liquid was poured into each of the openings in several nests, a quart to each opening. In every case it was found that the destruction of the colony followed after one or two applications. The cost of this method is small, but of course will assume considerable proportions in areas where the ants are very numerous. Even under such conditions it will undoubtedly well pay for the expense and is advised above all methods that can be followed.

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[1] The use of potassium cyanid in water solution against ants was first followed by Messrs. R. S. Woglum and Wm. Wood. (See Journal of Economic Entomology, vol. 1, pp. 348–349, 1908.) Mr. H. O. Marsh has also used it. (See Bul. 64, Pt. IX, U. S. Dept. Agr., Bur. Ent., pp. 74–78, 1910.)

The use of carbon bisulphid is not practical on account of the very extensive excavations the ants make in the sand. Some may be killed, but effective work can not be done unless the insecticide is forced into the earth by pressure, and this requires special apparatus. Moreover, the expense would be much greater than in the case of the cyanid method just described.

Some years ago certain persons in southern Texas followed the destruction of this ant as a regular business. They used sulphur and a special apparatus for forcing the fumes into the nests. The machine consisted of an oven in which the sulphur was burned. The fumes were passed through a pipe by forced draft, and the end of this pipe was inserted into the ground in the middle of the colony. Before the oven was started all of the openings of the nest were carefully closed. It is said that remarkable success accompanied this method. It may be found to be advisable to use this method for large areas of the infested lands or where several planters can cooperate.

Mr. C. L. Marlatt has described a method of destruction of ants which is in use in Cuba:

> It consists in digging a hole 6 feet deep by 3 or 4 feet wide in the midst of the colony. This hole is filled with dry brush and a roaring fire started. Into this is then poured a bucketful of powdered sulphur. The opening is closed with a large iron plate. Through a hole in the center of this plate air is forced down into the burning mass with a large bellows.[1]

THE AGRICULTURAL OR HILLOCK ANT.

(*Pogonomyrmex barbatus molefaciens* Buckley.)

The nests of the agricultural or hillock ant (*Pogonomyrmex barbatus molefaciens* Buckley) are conspicuous in the territory in which they occur on account of the fact that the ants do not allow any vegetation to grow in a circular area about them. The mounds are 15 inches or more in diameter and are frequently covered with particles of earth or sand from beneath the surface which contrast strongly with the surrounding soil. The bare areas around the mound may be 10 feet or more in diameter.

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[1] See W. M. Wheeler: Ants, their structure, etc., p. 577, 1910.

DISTRIBUTION.

The agricultural ant occurs from the Brazos River westward. West of San Antonio it is replaced by closely allied forms. Farther north, in Kansas and Nebraska, a distinct species (*P. occidentalis* Cress.) occurs. The agricultural ant is conspicuously a resident of open places and does not occur in wooded localities.

HABITS.

This ant swarms early in the season, generally after a rain. At such times the males and females come out of the nest in great numbers, covering the ground for many feet. Mating takes place at this time, after which the females fly away. When they alight their wings are cast and they begin to dig a cell for a new colony. The males after mating are driven away by the workers or killed if they persist in returning to the nest. At the time of this swarming multitudes of the ants are destroyed by birds and horned lizards.

Many years ago it was announced that the agricultural ant actually plants certain grasses in order to obtain quantities of seed to use in provisioning the nests. In fact, it was on this supposition that one of the common names which have come into use was given it. Upon careful investigation, however, it was found that the ant does not plant seed intentionally, although it undoubtedly does so accidentally. The facts were brought out by Prof. W. M. Wheeler. The seeds of several species of grass and common weeds are taken into the nests. When the moisture is too great in the nest some of these seeds sprout and thus become unsuitable for food. Under such circumstances the ants carry out the sprouted seeds and deposit them in the immediate vicinity of the nest where many take root and grow. Of course, this can not be considered intentional planting of the seeds, because the ants deal with the sprouted grain exactly as they would with any substance that was unsuitable in their nests; that is, they simply carry it out and throw it away.

DAMAGE.

The economic importance of the agricultural ant is due to the fact that it will not allow vegetation to grow in the immediate vicinity of its nest and to its powerful sting which it uses on the slightest provocation. If the colonies happen to be in fields such as alfalfa, corn, or cotton, the area of loss may amount to considerable, and the same is true to a certain degree of pasture and range lands. Moreover, in fields which are mowed the mounds interfere with the working of the machine, and the ants are likely to attack the horses. There is some degree of compensation for the loss of the land cleared by the ants. It will be noted that in a circle just outside of the area that is cleared the plants grow with great luxuriance. Frequently these plants become quite conspicuous in the field. This redoubled growth is due apparently to the fact that the underground tunnels of the ants loosen up the soil and have somewhat the effect of deep plowing. It is not likely that the increased growth under these conditions offsets entirely the loss in the area where no plants are allowed to grow, but it is sufficient to reduce the importance of the insect to some extent. Mr. J. D. Mitchell, who has made many careful observations on this species, believes that the actual damage inflicted is generally overestimated.

The sting of the agricultural ant is at least as severe as that of a bumblebee. It is speedily inflicted on any animal that approaches the nest. Consequently, colonies located in the vicinity of houses or on roads or paths frequently become decided nuisances. The best local applications for stings are aqua ammonia or bicarbonate of soda (baking soda). When fainting or dizziness occurs, as is frequently the case, a few drops of ammonia taken internally will be helpful.

NATURAL ENEMIES.

Natural enemies exert some repressive influence upon agricultural ants. The most important enemy among the birds is the great-tailed grackle (*Megaquiscalus major macrourus*), commonly known as the jackdaw. The following additional Texas birds are known to prey upon species of Pogonomyrmex, according to records in the Biological Survey: Upland plover (*Bartramia longicauda*), burrowing owl (*Speotyto cunicularia hypogœa*), Texas nighthawk (*Chordeiles acutipennis texensis*), scissor-tailed flycatcher (*Muscivora forficata*), kingbird (*Tyrannus tyrannus*), redbird (*Cardinalis cardinalis*), and mockingbird (*Mimus polyglottos*). The horned lizard (*Phrynosoma cornutum*) includes agricultural ants as a part of its regular diet.

REPRESSION.

As in the case of the cutting ant, the destruction of this species can best be brought about by the use of the solution of potassium cyanid in water. Mr. J. D. Mitchell conducted experiments at Victoria, Tex., which showed that this was a perfectly satisfactory method. It is much cheaper and easier of application than in the case of the cutting ant on account of the fact that the underground portion of the nest is much less extensive. A pint of liquid is sufficient for even a large colony, though sometimes a second application may be necessary.

Carbon bisulphid is also a good remedy and can be applied in a very simple manner. All that is necessary is to pour about 2 ounces into the opening of the nest. The opening need not be closed. As the gas is much heavier than air, it sinks into the innermost recesses and kills all of the ants in the colony. Setting fire to the liquid is of no benefit. In fact, it is likely to lessen its efficiency. The poison may be applied at any time of the day, regardless of the number of the ants that are outside the nest. The destruction of the colony depends upon the killing of the queen, and she remains in the nest at all times, except when the swarming flight is under way, for a very short time in the spring.

Sometimes Paris green or other arsenicals are used in the attempt to control this species. They are generally applied by simply pouring a handful into the openings. Many of the ants are killed, but a large part of the brood is not affected, and the colony soon becomes as numerous as ever. In some cases where this method has been followed persistently the ants have moved their nest a few feet away and have become reestablished perfectly in a short time. For these reasons the use of arsenicals can not be considered satisfactory.

Another method sometimes followed, which is of little practical use, is trapping the ants in bottles. If a large bottle is buried in the ground in the vicinity of the nest with the neck flush with the surface the ants soon begin an exploration and fall inside. The noise they make in the bottle attracts many others. In this way in the vicinity of a populous colony a large bottle may be filled in a short time. The objection to this procedure is that it only reduces the strength of the colony. The immature stages and the queen are not affected, and the colony soon regains its former numbers.

Approved:
JAMES WILSON,
Secretary of Agriculture.

WASHINGTON, D. C., *January 18, 1912.*

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